RESEARCH in Progress

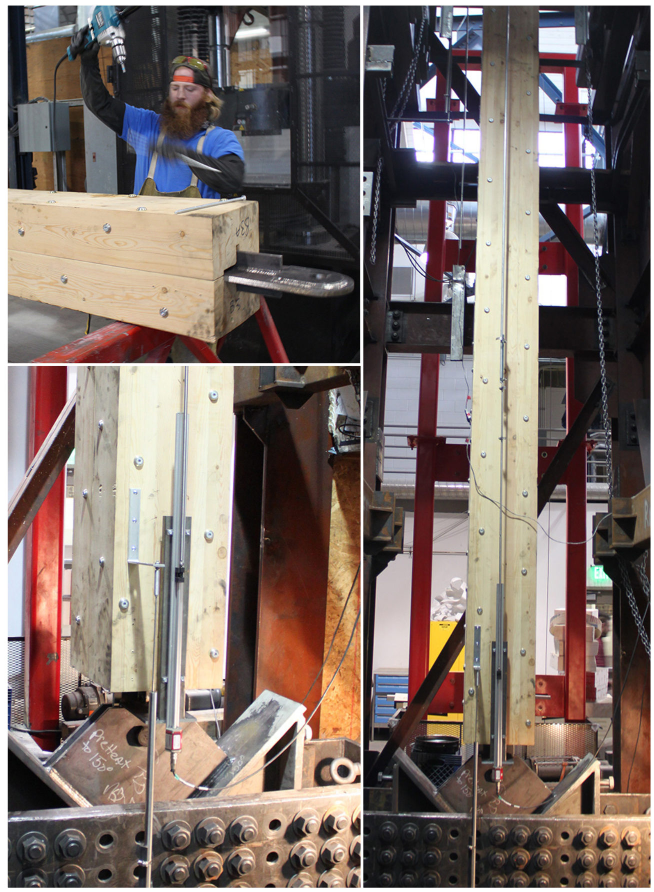
Forest Products Laboratory

Development of Heavy Timber Buckling-Restrained Braced Frames

Buckling-restrained braced frames (BRBFs) are one of the newer types of seismic-force-resisting systems used in modern building designs. In BRBFs, the primary source of ductility is the axial yielding of the buckling-restrained brace (BRB) cores, and BRBFs have improved ductility in comparison to ordinary or special braced frames. BRBs are incorporated into frame structures to dissipate energy or prevent damage to the surrounding structures. Frame systems employing this type of BRBs have demonstrated improved ductility and are currently an approved seismic-force-resisting system in the ASCE 7-10 code document (ASCE 2010).

Background

Timber building construction has been traditionally utilized to reduce inertial demands in high seismic regions. Applications in the United States, however, are often limited to low-rise buildings of light-wood construction with distributed load-bearing shear walls. Recent advancements in timber technologies are pushing mass timber systems into larger commercial-scale markets where steel and concrete systems dominate the landscape. In high seismic regions, mass timber buildings currently are not included in the ASCE 7 code defined lateral force-resisting systems and are limited to traditional timber-framed systems with low ductility. Building on over 40 years of existing BRBF research for steel and concrete buildings, the development of a heavy timber buckling-restrained braced frame (HT-BRBF) could improve ductility. A HT-BRBF system is conceived for application in mid- and high-rise building timber construction and is inspired by the unbonded steel brace technology that today is widely used throughout Japan and the United



Wood-based buckling-restrained brace testing.

States. A key need to move this lateral force-resisting system into codes is the development of a wood-based BRB that is compatible with the HT-BRBF.

Currently constructed BRBs consist of a steel core encased in a surrounding material that restrains the global and local buckling of the core. This surrounding material is typically a concrete-filled steel tube.

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As the name states, the BRB assembly restrains steel core buckling under compressive loading and achieves a compressive yield strength that is approximately equal to its tensile yield strength. Existing BRB capacities are incompatible with HT-BRBF. Using structural composite lumber in place of concrete, together with fully threaded self-tapping strength screws, a compatible heavy timber BRB (HT-BRB) alternative can be developed and easily incorporated into existing timber frames to improve seismic performance. Initial work by Blomgren and others (2016) highlighted the concept of HT-BRB with a 5/8-in. steel core that was sandwiched between two glued-laminated beams that were held together with fully threaded high-tensile-strength screws. Proof-of-concept testing at the University of Utah of three types of HT-BRBs has been completed. More systematic development and understanding of the HT-BRB is needed to qualify the system for future implementation in building codes.

Objective

The HT-BRB is an important component of the HT-BRBF. Research will optimize the concept by providing a better understanding of the fundamental timber casing behavior and limit states of a HT-BRB consisting of a steel core with a wood-based casing acting as the buckling restraint mechanism. This optimization is a necessary step towards economy and commercialization.

Approach

Both small-scale material and full-scale BRB testing will be conducted. Three types of structural composite lumber—glued laminated timber (glulam), laminated veneer lumber, and parallel strand lumber—will be investigated to replace the concrete-filled steel tubes. Small-scale testing will develop stress–strain curves describing the performance of the three types of structural composite lumber in cross grain bearing compression, including modulus of elasticity, with and without compression reinforcing screws, which are used in the design and construction of the HT-BRB.

Based on the small-scale tests, various full-scale HT-BRBs will be designed, constructed, and tested. Full-scale testing will validate the BRB design methodology and at the same time provide cyclic performance data required for design and codification of the HT-BRBF mass timber lateral-force-resisting system.

Expected Outcomes

The principal outcome of this project will be a BRB design methodology incorporating heavy timber. Additionally, cyclic performance data will be generated to allow both design and codification of the HT-BRBF system for use in high seismic and wind regions of the United States.

Timeline

Research will begin in January 2017 and be completed by December.

Cooperators

USDA Forest Service, Forest Products Laboratory

University of Utah

Arup USA

U.S. Endowment for Forestry & Communities

Contact Information

Douglas R. Rammer
USDA Forest Service, Forest Products Laboratory
Madison, Wisconsin
(608) 231-9266; drammer@fs.fed.us

Chris P. Pantelides
Civil and Environmental Engineering Department
University of Utah
Salt Lake City, Utah
(801) 581-6931; c.pantelides@utah.edu

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